Bio*Ag* Digest-it® for Dairies – A Powerful Tool in Dairy Effluent Management.

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Overview

Bio*Ag* Digest-it® for Dairies (Digest-it) is a new product in the Bio*Ag* Pty Ltd range of naturally fermented biologically active agricultural support products. It assists in the digestion of dairy effluent sludge by promoting aerobic bacterial metabolism. This on-going trial was designed to show proof of concept of the product and by way of routine analysis, attempt to quantify the advantages to Digest-it users primarily in terms of increased pond capacity and nutrient recovery. The trial commenced in November 2008 and will continue until at least 12 months worth of data is collected.

Trial Design

Four dairy properties in Victoria and New South Wales were selected to be part of the trial. The selection of trial partners was by way of introductions from Bio*Ag*'s distribution partner - Semex Pty Ltd, and differing herd sizes and effluent handling systems were sought. All four ponds are being tested on a three weekly cycle for a range of physical parameters.[2] As well, one pond is being tested for changes in a chemical profile.[3]

Visual and olfactory observations are taken on each visit. In addition, still and video images are recorded.

The physical testing profile is being carried out by the laboratories of Rockdale Beef Pty Ltd and the chemical testing profile by The National Measurement Institute.

<u>Merrigum [Vic.]</u>

This 110 cow dairy has a small effluent pond that was a real problem to the owner. It needed regular mechanical de-sludging and capacity was limited by the heavy crust and build up of solids on the bottom. The crust was thick and heavy enough to partially support the weight of a cow.

<u>Katunga [Vic.]</u>

The 100 x 30 metre pond should have been adequate for this 610 cow dairy, but the owner was having problems with odour, crusting and the pond overflowing into a nearby community drain. Regular mechanical cleaning was costing the owner over $6000 per episode.

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Blighty [NSW]
This 50 x 25 metre pond is taking the effluent from a 500 cow dairy. It has a relatively short fluid retention time. At the start of the trial it was heavily crusted and in poor condition. Since it seemed the pond in the poorest condition, this pond was chosen to for the chemical profile testing.

Finley [NSW]
Originally built for a 300 cow dairy, this pond is now servicing approximately 700 cows, in two groups twice a day. Build up of material on the bottom of the pond had blocked the drain to the irrigation system and crust build up had made the overflow difficult to manage.

Application
Each pond was 'charged' by applying 10 to 40 litres of diluted Digest-it to the pond surface using a high pressure pump. After this two to four litres of neat product has been poured onto the wash down pad before cleaning. This is then washed into the pond along with the effluent from that milking and the wash down water. This happens once per day. Application rates were individualised for each pond. The initial application and some subsequent daily applications had occurred before the initial sampling run.

Results
Pond Capacity
It is clear from visual observations and feedback from our trial partners that the use of Digest-it has increased pond capacity. This is clearly indicated in Illustration 1. In March 2009 the pond at Katunga was removed from the trial as the owner was able to move from a one pond system to a two pond set-up. The partially dissolved crust and increased fluid volume had meant that there was enough liquid to charge the waiting second pond. Associated with the increase in volume was generally cleaner water which is now being used for washing down the pad. The decrease in total water volume in the first pond has also meant that the remaining crust is breaking down at a greater rate than previously.

Illustration 1: Merrigum

26 November 2008

31 March 2009

pH

Most untreated effluent ponds are slightly alkaline. Examples are 7.9 for Queensland[4] and 7.3 for the Gippsland in Victoria.[5] The average pH of the four treated ponds in the Digest-it trial is 7.0. This change ensures that there is no risk of alkaline burn when pastures are irrigated with treated water.

Total, Dissolved and Suspended Solids

The results from these tests have been variable, resulting from activity within the pond at the time of sampling, and sampling variability. Feedback from our trial partners, especially at Katunga, indicates that the water is becoming clearer and visually cleaner.

BOD_5[6]

This generally recognized indicator of water health has shown a steady downwards trend in all four ponds. Published data[7] for north east Victoria suggests that the BOD_5

[4] Effluent and Manure Management Database for the Australian Dairy Industry (2008)
[5] Dairy Effluent – Application to Pastures. Victorian DPI [AG0419]
[6] See Appendix B
[7] Effluent and Manure Management Database for the Australian Dairy Industry (2008)

value of untreated ponds is in the range of 2,500-3,000 mg/l. Table 1. shows the BOD_5 values of the trial ponds averaged over quarterly periods.

Table 1. Digest-it Treated Ponds BOD_5 Test Results			
Location	Quarter 4 [2008]	Quarter 1 [2009]	Quarter 2 [2009] [8]
Merrigum	272	178	244
Katunga	412	409	NS[9]
Finley	934	404	437
Blighty	521	308	447

Aerobic/Anaerobic Index[10]

One of the claims made by Bio*Ag* for the use of Digest-it is that it increases the total number of aerobic bacteria in the system, and that this increase leads to better metabolism and nutrient conversion. To show this we are using an aerobic/anaerobic ratio. Table 2. shows the changes in this ratio over the four trial sites. In general terms the ratio is trending upwards showing an overall increase in aerobic bacteria.

Table 2. Digest-it Treated Ponds Aerobic/Anaerobic Ratio Results							
Location	26.11.08	17.12.08	07.01.09	28.01.08	10.03.09	31.03.09	21.04.09
Merrigum	9.7	18.0	6.4	38.6	NS[11]	11.7	18.3
Katunga	4.8	27.2	18.2	55.6	NS[12]	NS[13]	NS[14]
Finley	2.7	9.9	5.1	14.9	9.2	26.9	27.5
Blighty	5.7	61.0	4.7	10.4	11.9	24.8	41.2

NPK Ratio

There is a good deal of variation in the individual results for the Kjeldahl Nitrogen, Total Phosphorus and Total Potassium results. This could be due to the activity of the pond and time of sampling, the weather conditions and sampling variation. However some trends are developing both within the pond at Blighty and when compared against published data for untreated ponds, Table 3. shows the results from Digest-it treated ponds compared with industry data.

Table 3. shows the Queensland and the average of three Victorian regions compared against monthly NPK analyses for the Blighty site. The results are expressed in mg/l. The unit is equivalent to kg/ML if the treated water was used for irrigation water. The data show that nutrient levels in the treated pond are such that for a typical irrigation application rate the pond water now needs to be diluted to avoid nutrient overload. By analysis we have found that over 95% of the total phosphate is in a bioavailable form.

[8] Incomplete data set at compilation date
[9] No sample
[10] See Appendix B
[11] No sample
[12] No sample
[13] No sample
[14] No sample

Table 3. NPK Nutrient Levels (mg/l)									
Parameter	Qld[15]	Vic[16]	11.08	12.08	1.09	2.09	3.09	4.09	Bio*Ag* Mean
Nitrogen	167	283	520	650	465	515	620	520	551
Phosphate	36	76	120	130	135	120	140	140	131
Potassium	274	409	940	1,030	960	570	660	640	817

Other Nutrients

Table 4. shows the levels of other nutrients in the treated pond at Blighty and the average result for four untreated ponds tested by Bio*Ag* on behalf of clients.

Table 4. Nutrient Levels (mg/l)		
Parameter	Untreated Ponds	Blighty [NSW]
Calcium	220	200
Magnesium	131	212
Chloride	356	1,300[17]
Ammonia	210	300

Odour

Odour is essentially at this stage, an amenity issue. There is no doubt that one of the first things that is noticed by all users of Digest-it is a reduction in the offensive odour normally associated with untreated effluent ponds.

Discussion

This has been an interesting trial to run. We are dealing with a dynamic biological system. The owners of the trial sites have continued to utilize the ponds at all times. Fluid has been drained, effluent added, rain has come and gone and our trial partners have been in charge of dosing the pond - not always according to our recommendations. There is considerable biological 'bounce', so rather than rely on each data point, it is more meaningful to look at the trend patterns appearing.

Effective pond capacity has undoubtedly increased. See Illustration 1. as an example. All ponds in the trial display similar increases in effective capacity. The Blighty site is the slowest mover in this regard.

One of the claims made for Digest-it is the increases in aerobic bacteria and increases in digestion rates. The increase in the ratio of aerobic bacteria to anaerobic populations is effectively shown in Table 2. Again the trend is upwards.

[15] Effluent and Manure Management Database for the Australian Dairy Industry (2008)
[16] Dairy Effluent – Application to Pastures. Victorian DPI [AG0419]
[17] All water used in the dairy is from a bore, this may be a contributing factor to the chloride level.

There is no doubt that the BOD_5 of our trial ponds is lower than industry datum points and the trend is that the BOD_5 is continuing to drop over time. This is a useful thing, when discussing the system with Regulatory bodies.

I am also of the opinion that nitrogen and phosphate values are trending upwards as sludge from the bottom of the ponds is dissolved. There is a considerable nutrient 'bank' in the sludge, as in associated testing at the Blighty site the nitrogen level of the sludge was just under 2%.

Potassium levels although initially higher than industry data are decreasing. Some of the higher than expected levels may be that the Blighty dairy uses only bore water; at this time I do not have a water analysis for this site. However the potassium trend appears to be sloping downwards. This may be due to dilution as the effective pond capacity increases.

In an untreated pond, most of the potassium is in solution and most of the nitrogen and phosphate is locked in the crust and the sludge. As Digest-it continues to stimulate the digestion process more of the nitrogen and phosphate will be released into the liquid phase, and the potassium levels will decrease due to dilution; then all three essential nutrients may come into balance. Currently the risk of potassium overload limits the amount of effluent that can be employed for irrigation. This than can lead to the need to 'top-up' the nitrogen and phosphate levels of effluent irrigated pastures; it is likely that Digest-it will reduce this requirement.

While odour is essentially an amenity issue, the reduction in the release of Hydrogen Sulphide (rotten egg gas) indicates that more sulphur is being trapped in the system. It may well be that nitrous oxide compounds (NOXs) are also being captured. With increasing urban creep and mixed farming communities, it is certain that odour will become a more important issue over time.

Conclusion
Taken as a complete package, the trial data supports the claims made by Bio*Ag* with relation to the use of Digest-it® for Dairies. It is indeed a powerful tool in effluent management.

14.05.09

APPENDIX A

Analytical Testing – Digest-it® for Dairies Project [Bio*Ag* Pty Ltd]

Aim

In setting up the analytical testing regime we were looking for a key or keys that would give a clear indication that Digest-it® for Dairies is working in the trial ponds. Before this we were relying on visual and olfactory indicators. Because the nature of the key(s) was unknown, we aimed at a broad spectrum of testing.

Scope of this Paper

In this paper I have attempted to explain each component of the current testing regime. Also, there is some indication as to whether or not the indices are adding value to our analysis profile and, for some, the direction we would like to see them moving.

Physical Test Profile

A definition section is included at the end of this paper which may help with understanding some of the testing parameters.

Total Plate Count (TPC)

TPC are being measured both for both aerobic [TPC (O_2)] organisms and anaerobic [TPC (AN-O_2)] organisms. Aerobic TPCs are being performed at two different temperatures to capture the majority of aerobic organisms.

Associated with these tests is an Aerobic: Anaerobic Ratio [Total Aerobes divided by Total Anaerobes]. We are looking to turn the ponds from a predominately anaerobic system to an aerobic one. The trend in all our four ponds is that the ratio is increasing, indicating that the desired outcome is being achieved.

Biochemical/Biological Oxygen Demand (BOD_5)

This measures the amount of oxygen demanded by the water biology. It is a five day test. Because we are working in a sewage system, these values are obviously much higher than other waters, but as the biology change then the BOD_5 moves around. The trend on all ponds is downwards this is the way any waste authority looking at the results would like to see it going.

Chemical Oxygen Demand (COD)

As the definitions explain, COD is the total oxygen demand of the system. It takes into account both organic and inorganic demand. It is associated with the BOD_5 and isn't really adding value to our observations at this time

Dissolved Oxygen ($DisO_2$)

As the name implies, this is a measure the level of oxygen in the sample. It is necessary parameter in determining the BOD_5 and the COD, but by itself isn't adding value to our observations.

Conductivity

This is a measure of the charged ions in the sample. It is a term understood by most of our potential clients in relationship to irrigation and groundwater water levels. Levels in our ponds aren't changing much indicating (as one might expect) relatively high levels of ions in the ponds.

pH

The ponds are maintaining a pH level from neutral to slightly alkaline.

Turbidity

This is a measure of how murky the sample is. This parameter is varying somewhat, but is most likely reflecting sampling differences and microbial activity in the pond at time of sample. By itself isn't adding value to our observations.

Solids – Total (TS), Suspended (TSS) and Dissolved (TDS)

Again these results are varying, especially TS and TSS readings. The variation could be due to some extent to sampling variations, but mostly they reflect the activity of the pond at time of sampling. On days of high activity (bubbling/"bolling") then the TS and TSS seem to be higher than on quiet days. While ever there is material to be digested I would expect these results to continue to be variable.

Chemical Test Profile

We are conducting the Chemical Test Profile on only one of our four trial ponds. At the time of setting up the trial profile, this was the least advanced of our ponds and hopefully over time will give a good indication of changes to the indices as Digest-it has its effect.

Calcium (Ca), Magnesium (Mg), Potassium (K) and Chlorine (Cl)

These need no explanation and represent the levels of those elements in the respective sample. Increases in calcium, magnesium and potassium would be good, increases on chlorine less so.

Phosphates

We are measuring three phosphate variants: Total Phosphate –a measure of all the phosphate that is available in the system, Bioavailable Phosphate –a measure of phosphate salts, Organic Phosphate (from flora) and other acid soluble sources of phosphate. It excludes mineralized phosphate. As can be seen from the results, all the phosphate in the system seems to be in a bioavailable form. Soluble Orthophosphate Phosphate is essentially phosphate in solution. While we held out hope in the early days that this would prove a useful indicator, as time goes on I'm less convinced as to its usefulness.

A large proportion of the phosphate in the system is tied up in the sludge and over time we would like to see an increase in Total Phosphate and Bioavailable Phosphate.

Sodium Absorption Ratio (SAR)

This ratio measures the ratio of sodium ions to calcium/magnesium ions. A high SAR would indicate waste water unsuitable for use as irrigation water. Based on information from the Qld DPI website (see Definitions) the use of gypsum on paddocks irrigated from our test pond may also be indicated

Nitrogen

Again we are measuring a number of nitrogen parameters. Kjeldahl-N is the total nitrogen and includes the all organic and inorganic N sources. See the definitions at the end of this paper for a more detailed explanation of the nitrogen parameter. Up to 50% of the excreted N may be lost from the system through volatilization. However, another approximately 20% is tied up in the sludge component, and as we digest this sludge we would expect an upwards trend in overall N levels.

APPENDIX B

Definitions

Taken from a number of Internet sources

Chemical Oxygen Demand (COD)

The amount of **oxygen** (measured in mg/L) that is consumed in the oxidation of organic and oxidisable inorganic matter, under test conditions. It is used to measure the total amount of organic and inorganic pollution in wastewater. Contrary to BOD, with COD practically all compounds are fully oxidized.

http://en.mimi.hu/environment/chemical_oxygen_demand.html

Chemical Oxygen Demand (COD): A measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water.

http://www.water-technology.net/glossary/chemical-oxygen-demand.html

Biochemical Oxygen Demand (BOD)

The amount of **oxygen** (measured in mg/L) that is required for the decomposition of organic matter by single-cell organisms, under test conditions. It is used to measure the amount of organic pollution in wastewater.

http://en.mimi.hu/environment/chemical_oxygen_demand.html

Biochemical Oxygen Demand (BOD): A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

http://www.water-technology.net/glossary/chemical-oxygen-demand.html

Turbidity

- Turbidity is a measure of cloudiness in water. The more turbid the water, the murkier it is.
- Turbid waters become warmer as suspended particles absorb heat from sunlight, causing oxygen levels to fall. (Warm water holds less oxygen than cooler water.) Photosynthesis decreases with lesser light, resulting in even lower oxygen levels.

Dissolved Oxygen

- Fish, invertebrates, plants, and aerobic bacteria all require oxygen for respiration.
- Much of the dissolved oxygen in water comes from the atmosphere. After dissolving at the surface, oxygen is distributed by current and turbulence. Algae and rooted aquatic plants also deliver oxygen to water through photosynthesis.
- The main factor contributing to changes in dissolved oxygen levels is the build-up of organic wastes. Decay of organic wastes consumes oxygen and is often concentrated in summer, when aquatic animals require more oxygen to support higher metabolisms.

pH

- A range of pH 6.5 to pH 8.2 is optimal for most organisms.

Biochemical Oxygen Demand

- Biochemical oxygen demand is a measure of the quantity of oxygen used by micro-organisms (e.g., aerobic bacteria) in the oxidation of organic matter.
- Oxygen consumed in the decomposition process robs other aquatic organisms of the oxygen they need to live. Organisms that are more tolerant of lower dissolved oxygen levels may replace a diversity of more sensitive organisms.

Nitrates

- Nitrogen occurs in natural waters as nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and organically bound nitrogen.
- Excessive nitrates stimulate growth of algae and other plants, which later decay and increase biochemical oxygen demand as they decompose.

Total Phosphate

- Phosphorus is usually present in natural water as phosphates (orthophosphates, polyphosphates, and organically bound phosphates).
- Phosphorus is a plant nutrient needed for growth and a fundamental element in the metabolic reactions of plants and animals (hence its use in fertilizers).

Conductivity

- Conductivity is also a good measure of salinity in water. The measurement detects chloride ions from the salt. Salinity affects the potential dissolved oxygen levels in the water. The greater the salinity, the lower the saturation point.

Ammonia

- Nitrogen occurs in natural waters as nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and organically bound nitrogen.

http://www.fivecreeks.org/monitor.html

Nitrate (NO3), Nitrite (NO2), and Ammonia (NH4)

- Are considered inorganic forms of nitrogen and are analysed separately in wastewater's to determine the total inorganic nitrogen.

Total Kjeldahl nitrogen (TKN)

- Is the combination of organically bound nitrogen and ammonia in wastewater. The organically bound nitrogen must be released from the organic matter by a process of digestion prior to analysis. This form of nitrogen is usually much higher on influent (untreated waste) samples then effluent samples. In most domestic wastewater facilities the biological activity breaks down the organic matter releasing and or consuming the nitrogen as energy in the process. Total nitrogen is the combination of organic nitrogen and inorganic nitrogen (NH4, NO3, NO2).

http://www.bfhd.wa.gov/info/tkn.php

Solids Analysis

- Solids are categorized into several groups based on particle size and characterization. Most wastewaters are analysed for one or several of the following types.

Total Suspended Solids (TSS)
Total Dissolved Solids (TDS)
Total Solids (TS)

Analysis of solids in domestic wastewaters allow system operators to determine treatment efficiency as well as determining compliance with various regulatory agencies.

Total Suspended Solids

TSS are the amount of filterable solids in a water sample. Samples are filtered through a glass fibre filter. The filters are dried and weighed to determine the amount of total suspended solids in mg/l of sample.

Total Dissolved Solids

TDS are those solids that pass through a filter with a pore size of 2.0 micron. or smaller. They are said to be non-filterable. After filtration the filtrate (liquid) is dried and the remaining residue is weighed and calculated as mg/l of Total Dissolved Solids.

Total Solids

TS are the total of all solids in a water sample. They include the total suspended solids, total dissolved solids, and volatile suspended solids.

http://www.bfhd.wa.gov/info/tss.php

Sodium adsorption ratio (SAR)

The sodium adsorption ratio measures the relative proportion of sodium ions in a water sample to those of calcium and magnesium. The SAR is used to predict the sodium hazard of high carbonate waters especially if they contain no residual alkali.

The sodium adsorption ratio is used to predict the potential for sodium to accumulate in the soil, which would result from continued use of a sodic water, referred to as the **Exchangeable Sodium Percentage (ESP).** A water sample with a high SAR and a low RA usually has high sodium content due to the predominance of sodium chloride.

Table 2. Sodicity classes for irrigation water

Sodium adsorption ratio	Residual alkali	Sodicity class
Less than 3	Less than 1.25	No sodium problem
3 to 6	Less than 1.25	**1.** Low sodium, few problems except with sodium sensitive crops.
6 to 8	Less than 2.5	**2.** Medium sodium, increasing problems; use gypsum and not sodium sensitive crops.
8 to 14	Less than 2.5	**3.** High sodium - not generally recommended.

http://www2.dpi.qld.gov.au/fieldcrops/3472.html